Quasi-ordered photonic structures colour the bluespotted ribbontail ray

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Quasi-ordered photonic structures colour the bluespotted ribbontail ray

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Abstract: Due to the scarcity of blue colour exhibited by natural organisms, highlighting the underlying this colour mechanisms is always very impactful for the understanding of the natural world. In this research, the colour of the blue rounded spots occurring in the skin of *Taeniura lymma* stingray was unveiled by a combination of experimental and numerical techniques. Our results demonstrated that this blue colour arises from coherent scattering in quasi-ordered photonic structures occurring in the skin of this stingray.

Blue is often described as the rarest colour in natural organisms [1]. Elucidating the underlying mechanism(s) giving rise to such a hue is always very impactful for the understanding of the natural world in which human beings live. In this research, the colour of the blue rounded spots occurring in the skin of the bluespotted ribbontail ray *Taeniura lymma* was unveiled by a combination of experimental and numerical techniques. Histological observations were carried out with optical, fluorescence and transmission electron microscopies. Optical characterisations were performed by spectrometry and microspectrofluorimetry. Numerical simulations were based on two-dimensional fast Fourier transforms of electron micrographs of the observed structures and Benedek's theory relating Fourier transform of spatial variation in refractive index to the intensity of coherent scattering [2]. Our results demonstrated that the blue colour of this ray arises from coherent scattering in quasi-ordered photonic structures occurring in the skin of this animal. This type of structures made of collagen fibres is mostly unknown in marine species. In addition, structural blue colours had never been reported in elasmobranches.

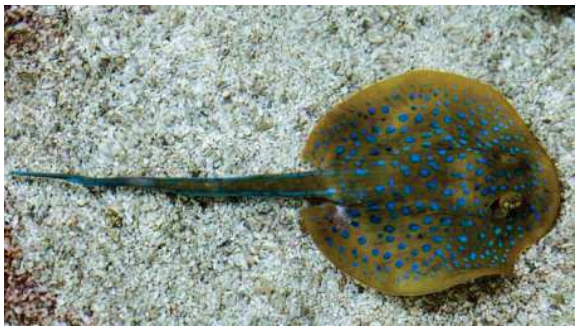

Figure 1. The blue spots occurring in the integuments of *T. lymma* arise from quasi-ordered photonic structures. Photograph by Taken reproduced from https://pixabay.com/photos/ray-stingray-fish-sea-ocean-539788/

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References

1. Mouchet, S. R. and O. Deparis, Natural Photonics & Bioinspiration, Boston: Artech House, 2021.
2. Benedek, G. B., “Theory of Transparency of the Eye,” Applied Optics, Vol. 10, No. 3, 459-473, 1971.